Rec'd PCT/PTO 14 DEC 2004 10/518321

REPLACED BY ART 34 AMDT

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

	Date of mailing *(day/month/year)* 13.09.2004	
Applicant's or agent's file reference S2433 GC/sta	IMPORTANT NOTIFICATION	
International application No. PCT/EP 03/06133	International filing date *(day/month/year)* 11.06.2003	Priority date *(day/month/year)* 14.06.2002
Applicant INFINEON TECHNOLOGIES AG et al		

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The Applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purpose of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purpose of deciding whether, in that State, the claimed invention is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

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Form PCT/IPEA/416 (January 2004)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or Agent's file reference S2433 GC/sta	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/EP 03/06133	International filing date *(day/month/year)* 11.06.2003	Priority date *(day/month/year)* 14.06.2002
International Patent Classification (IPC) or national classification and IPC H04M3/30		
Applicant INFINEON TECHNOLOGIES AG et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets including this title page.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Instruction 607 of Administrative Instructions of the PCT).

   These annexes consist of a total of 21 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement according to Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand 08.01.2004	Date of completion of this report 13.09.2004
Name and mailing address of the IPEA European Patent Office D-80298 Munich Tel. +49 89 2399 - 0, Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer: Liebhart, M Tel. +49 89 2399-7598

I. Basis of the report

1. This report has been drawn up on the basis of the following elements *(the replacement sheets received by the receiving office in response to an invitation according to Article 14 are considered in the present report as "originally filed" and are not annexed to the report as they contain no amendments (Rules 70.16 and 70.17).):*

Description, pages:

1-17	received on	04.06.2004	with the letter of	02.06.2004

Claims, No.:

1-13	received on	04.06.2004	with the letter of	02.06.2004

Drawings, sheets:

1/9-9/9 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been written disregarding (some of) the amendments, which were considered as going beyond the description of the invention, as filed, as is indicated below (Rule 70.2(c)):

   (All replacement sheets comprising amendments of this nature should be indicated in point 1 and attached to this report).

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-13
	No:	Claims	
Inventive Step (IS)	Yes:	Claims	1-13
	No:	Claims	
Industrial Applicability (IA)	Yes:	Claims	1-13
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Justified finding in accordance with Article 35(2) with regard to novelty, inventive step and industrial applicability; documents and statements to support this finding

The invention relates to a method for qualification of two-wire telephone lines for data transmission for frequencies above the conventional speech band.

In order to use this frequency range, it is necessary to qualitatively assess the line impedance and, in particular, to detect serial inductances.

In the present invention, the phase shift between a test signal that is fed in and a signal which is reflected on the telephone line is recorded. Furthermore, the second derivative of this phase shift (based on the frequency) is investigated for the presence of at least one mathematical sign change. If there is a mathematical sign change such as this, then the line is not suitable for such data transmission, at least without further technical actions.

The closest prior art (US-A-4 620 069) describes a method for tracing inductances on a telephone line. In this case, the impedance profile, that is to say the real and imaginary parts as well as the magnitude and phase, is analyzed for a range of measurement points. The profile of the real part and of the associated phase shift in this case allows classification on the basis of a loaded or unloaded telephone line.

Neither the document stated above nor the remaining available prior art provide any stimuli relating to this. Claim 1 therefore satisfies the requirement according to Article 33(2) and (3) PCT.

Claims 2-10 are dependent on Claim 1, and thus satisfy Article 33(2) and (3) PCT.

Furthermore, Claims 11 and 12 satisfy the requirement according to Article 33(2) and (3) PCT, which relate to the use of a DSL modem for carrying out the method according to the invention, with the data driver and receiving module in the DSL modem (Claim 11) being used on the one hand, and an existing test module for electrical test of the input resistance of the line being used on the other hand (Claim 12).

Claim 13 is dependent on Claims 11 and 12, and thus satisfies Article 33(2) and (3) PCT.

Furthermore, the following item should be borne in mind:

The method steps stated in Claim 1 are incorrectly defined in the form of bracketed expressions. In the rest of the document, the reference to these method steps in the dependent claims leads to lack of clarity (Article 6 PCT) if the bracketed expression is ignored.
In general, bracketed expressions are intended to be used only for reference symbols.

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DT01 Rec'd PCT/PTO 14 DEC 2004

Method for detection of impedances, method for qualification of telephone lines

The invention relates to a method for detection of impedances, in particular along inductances, in telephone lines of the type with two metal wires as signal conductors (twisted pair) according to the precharacterizing clause of Claim 1, and to a method for qualification of telephone lines of the type with two metal wires as signal conductors (twisted pair) for suitability for data transmissions based on the DSL Standard according to the precharacterizing clause of Claim 13, and to the use of a DSL modem for carrying out a method such as this.

In modern data transmission, which is used increasingly frequently and over ever larger areas, via conventional metallic telephone lines with two line cores (which are generally formed from copper wires), one problem that arises is that these lines, which were often laid decades ago, were not designed for transmission frequencies above 6 kHz.

Particularly in rural areas and in particular in the American area, lines have often been laid which were provided with so-called "load coils" in order to improve the transmission of frequencies in the range from 1 to 5 kHz. These are series inductances which were looped in pairs into the two line cores - provided with a common toroidal core - at regular intervals, for example with 66 mH in each case at intervals of 900 meters, or with 88 mH in each case at intervals of 1.2 km.

However, transmission frequencies above 5 kHz, in the range from several 10 to 100 kHz, must be possible for data transmission.

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This is impossible in the presence of impedances, in particular the inductances which have been mentioned, whose purpose was to reduce the attenuation in the speech band, since they represent an excessively high impedance for high frequencies.

Since there are often no accurate records relating to the type of lines, or to whether inductances were or were not laid, the line must be qualified before it can be used for data transmission.

This is expensive and highly time-consuming, particularly when telephone company employees have to be sent out in order to measure the line.

The object of the invention is to provide a method in which any impedances in a conventional telephone line can be detected at as low a cost as possible and with a high degree of reliability.

This object is achieved by a method for detection of impedances according to Claim 1, by the method for qualification of telephone lines according to Claim 13, and by use of a DSL modem according to Claim 14 and according to Claim 16.

The invention provides a method for detection of impedances, in particular along inductances (looped-in in series), in telephone lines of the type with two metal wires as signal conductors (twisted pair), comprising the following steps:
a test signal in the form of an AC voltage is fed into the telephone line,
a measurement signal of the reflection signal of the test signal is measured, which can be tapped off as the component, reflected on the input impedance of the entire line, of the test signal fed in at the start of the line,

the first method steps are carried out at a number of different frequencies within a preselected frequency range of the AC voltage of the test signal,
the profile of the measurement signals is analyzed as a function of the frequency, with
the derivative of the profile of the measurement signals being formed based on the frequency,
at which point the second derivative of the profile of the measurement signals is formed based on the frequency,
the profile of the second derivative of the profile of the measurement signals based on the frequency is investigated for one or more mathematical sign changes.

The invention proposes that an AC voltage signal be fed in, which is, of course, partially reflected on the overall input impedance of the line. This reflected signal is then investigated for the line resistance, in particular with clear information about whether there is an impedance in the line being obtained by investigation of the profile of the second derivative. This represents a considerable simplification in comparison to previous measurement methods, with a number of test steps which have to be carried out manually and individually.

One preferred method step provides for the AC voltage to be a sinusoidal AC voltage. A sinusoidal AC voltage such as this can be generated and detected easily on a DSL modem card.

One advantageous method step provides for the measurement signal to be obtained by measurement of the electrical voltage or of the electric current of the reflection signal.

The phase shift of the reflection signal with respect to the test signal is preferably recorded as the

measurement signal.

According to one advantageous refinement of the method, the phase shift is determined by means of a phase discriminator.

According to one refinement of the invention, which is likewise advantageous, the phase shift is determined by means of a quadrature demodulator.

One advantageous method step provides for the frequencies to be chosen to be between 1 and 5 kHz, in particular with regular or logarithmic intervals between the individual frequencies. The so-called load coils can be detected particularly well, especially in this frequency range.

One particularly advantageous and thus preferred method step provides that, before the second derivative of the profile of the measurement signals based on the frequency is formed, the individual measurement signals are averaged in order to smooth them in the profile. The smoothing is used to reduce the "noise components" (which are statistically independent with respect to the actual profile), and improves the capability to evaluate the data.

In consequence, median formation is carried out as the smoothing process according to one refinement of the invention.

One advantageous refinement of the method provides that, in a step which follows the median formation, individual smoothed measurement signals, which are at a regular interval from one another, are supplied for further evaluation. This leads to data reduction, which simplifies the evaluation process, and which does not result in any corruption of the results, owing to the

previous smoothing of the data.

The invention also provides a method for qualification of telephone lines of the type with two metal wires as signal conductors (twisted pair) for suitability for data transmissions based on the DSL Standard, on the basis of investigations, in particular using a method as described above, in which case, when a mathematical sign change occurs in a second derivative of the input resistance of the telephone line over the frequency in a preselected frequency range, the line is assessed as not being suitable for use without further technical actions for data transmissions based on the DSL Standard.

A further aspect of the invention provides for the use of a DSL modem for carrying out a method as described above, using the data driver and receiving module which is provided in the DSL modem that is used. This makes it possible to use already existing hardware in a particularly simple manner, without any need for further developments.

A further method which is provided by the invention proposes the use of a DSL modem at the network provider end for carrying out one of the methods mentioned above, in which case the test module which is present in the DSL modem that is used at the switching center end is used, which is often provided in a DSL modem at the network operator end, in order to make it possible to pass analog currents and/or voltages of different types to the line, and to measure them, in order in this way to make it possible to carry out an electrical test of the line. In this case as well, the advantages result from the use of already existing hardware.

Further advantages, special features and expedient developments of the invention result from the further

dependent claims or from sub-combinations of them.

The invention will be explained in more detail in the following text with reference to the drawing, in which, as is shown:

a detail of a telephone line with load coils,

an equivalent circuit of the line for low frequencies,

an equivalent circuit of the entire line with load coils for low frequencies,

the qualitative profile of the characteristic impedance Z as a function of the frequency,

the overall input impedance of the line plotted against the frequency,

the real part of the input impedance of the line plotted against the frequency,

the imaginary part of the input impedance of the line plotted against the frequency,

the phase shift of the input impedance of the line plotted against the frequency,

the first derivative of the phase shift of the input impedance as a function of the frequency for different constraints,

the second derivative of the phase shift of the input impedance as a function of the frequency for different constraints,

a flowchart of the method,

a measurement example of a measured and calculated first derivative,

a measurement example of a measured and calculated first derivative after averaging for smoothing,

a measurement example of a measured and calculated first derivative after data reduction has been carried out,

a measurement example of a calculated second derivative,

a schematic illustration of assemblies of a DSL modem,

a schematic illustration of those assemblies of the DSL modem which are involved in the evaluation process,

a module which is involved in the analysis based on a first example,

a module which is involved in the analysis based on a second example,

a schematic illustration of the DSL modem assemblies which are involved in the evaluation process for phase difference measurement, and

a schematic illustration of signal profiles for phase difference measurement.

Identical reference symbols in the figures denote identical elements or elements having the same effect.

Figure 1 shows a longitudinal detail of a telephone line from the start (feed points 11 and 12 for the two individual wires 13 and 14) of the line 10. Without the load coils 15 and 16 inserted in it, the characteristic impedance of the line is Zo.

The load coils in the example are looped-in in series (along the line) in the line at a distance of 2 km from the feed point, and then repeatedly after every 2 km. The coils are designed such that they reduce the line attenuation for frequencies in the speech band up to 3.4 kHz. However, at higher frequencies, the attenuation rises drastically, so that data transmission is impossible with all DSL methods.

It is thus necessary to use methods described here to determine whether an existing line is or is not provided with load coils, in order to determine its suitability for transmission methods which use considerably higher transmission frequencies (for example ISDN, VDSL, SDSL, ADSL).

The methods according to the invention allow such determination of suitability in the sense of the presence or absence of load coils in the line, without

any additional test equipment, using solely the existing hardware together with associated software.

Figure 2 shows the equivalent circuit of the line arrangement shown in Figure 1 for low frequencies, for which the line length as far as the coil (in the example 1 = 2 km) is very much shorter than the wavelength.

For simple estimation purposes, the line elements of the pure wire line can be combined to form concentrated elements, specifically to form a resistor 21 (R'), the coil 22 (L') and the capacitor 23 (C').

The characteristic impedance of the line is changed from Zo to Zc by the incorporation of the load coils. The input impedance is obtained by terminating the equivalent circuit with the characteristic impedance Zc.

Zc takes account of the load coils.

Zc thus has a high resistive and capacitive component for low frequencies, as is shown in the further simplified equivalent circuit as shown in Figure 3 by the switching element 30, which replaces the further line and the coils, with the resistor 31 (Rc) and the capacitor 32 (Cc).

The qualitative profile of the characteristic impedance plotted against the frequency w is shown in Figure 4. The graph shows the real part of Zo 41 and the real part of Zc 43 (that is to say when coils are present), as well as the imaginary part of Zo 42 and of Zc 44. The curves differ noticeably from one another. The difference will become even more clear in the following text. In this case, however, it can be seen that the profile of the input impedance also has "ripples" in comparison to a line without load coils.

Figures 5 to 8 show the influence of constraints at the end 18 of a first line section 13 composed of wire. Three curves are in each case plotted, with a denoting a value profile for a line which is open at the end 18, b denoting a value profile for a line which is connected at the end 18 via a load coil to a further piece of line, and c denoting a value profile of a line which is connected at the end 18, without any coil, directly to a further piece of line.

Figure 5 shows the magnitude of the input impedance of the line at the feed point (11, 12). Figure 6 shows the real part of the input impedance. Figure 7 shows the imaginary part of the input impedance and, finally, Figure 8 shows the phase shift of the input impedance of the line.

As can clearly be seen, the difference can be evaluated in all the values, but is strongest in the phase profile, which appears to suggest that evaluation of the phase profile is preferable.

In this context, Figures 9 and 10 once again show the typical profile of the phase shift of the first derivative (Figure 9) and of the second derivative (Figure 10) in more detail.

The described problem, that is to say the detection of the load coils, is solved by detecting the very different profiles of the characteristic impedances between a line with and without load coils in the lower frequency range (that is to say in the speech band), to be precise using the already existing hardware.

Figure 11 shows the procedure for the analysis part of the method after a test signal in the form of an AC voltage has been fed into the telephone line and the

phase shift of the reflection signal of the test signal has been measured as the measurement signal at a number of different frequencies. For illustrative purposes, Figures 12 to 15 show the processing of the data records, once again with the boundary conditions a, b and c (see above).

The analysis method steps are carried out as follows: Analysis of the profiles of the measurement signals, with the derivative 91 of the profile of the measurement signals based on the frequency being formed (see Figure 12 for a typical data record). The profile measurement signal is then subjected to averaging 92 by forming the median of the individual measurement signals in order to smooth their profile. In this case, by way of example, eight adjacent values may be smoothed jointly (see Figure 13 for a typical data record).

Data reduction 93 is carried out in the step following the median formation, in which only individual smoothed measurement signals, which are separated by regular intervals (for example only every eighth value) are supplied for further evaluation (see Figure 14 for a typical data record).

The second derivative 94 of the profile of the reduced smoothed measurement signals is now produced on the basis of the frequency (see Figure 15 for a typical data record).

All that now need be looked for is a mathematical sign change in the profile of the second derivative (95). These exist in lines which contain load coils, but no mathematical sign changes occur in lines without load coils. The mathematical sign change can be used to clearly deduce the presence (96) or absence (97) of load coils.

Figure 16 shows a typical DSL module 100, as may be used. This has a sine-wave generator 108, which supplies the signal via a transmission filter 105a and the digital/analog converter 105b to the hybrid 103 (which also contains a line driver). The hybrid 103 is connected directly to a transformer 104, via which the signal is fed into the line 10 on both wires 13 and 14. The DSL module receives signals from the line 10 again via the transformer 104 and the hybrids 103, and supplies the separated signal via an analog/digital converter 106b and a reception filter 106a to the echo compensation device 107. This is normally used to actually separate its own reflected signal.

Some DSL cards 100 also have a line test device 102, as is illustrated in the figure. This is able to pass analog signals (which are produced by means of signal generation devices 111 and 112) to the line 10, in order in this way to carry out fundamental functional tests of the line. For this purpose, by way of example, measured values which are dropped across resistors 113 and 114 are evaluated by means of an evaluation apparatus 115. The test may comprise simple resistance tests or the like (metallic loop test).

In order to carry out the method, the AM modulators in the transmission path can be used to produce the sinusoidal measurement signals. The reception path comprises the ADC 106b (analog/digital converter), the downsampling from the ADC sampling rate to the symbol rate, the RX filter 106a and the echo compensation 107. The echo compensation comprises the actual FIR echo compensator filter 107 and the adder 107a, which, in the data mode, subtracts the echo which is simulated by the echo compensator filter, from the filtered received signal (that is to say switched off in the method). For adaptation, the remaining echo is supplied, downstream

from the adder, to the adaptation part of the echo compensator filter. Furthermore, the reception path has an r*4kHz demodulator 107b, by means of which the data can be recovered during the G.hs procedure.

The arrangement of the hybrid and transformer likewise corresponds to the normal application. The transformer winding is split on the loop side, and the winding elements are connected to a capacitor in order to avoid a short circuit during power feeding. In this case, the hybrid should also contain the line driver, which may have an internal resistance Ri.

The method for detection in the transceiver will be described in the following text: transmission of a sine-wave signal. TX and RX filters connected as bandpass filters. Echo compensation switched off, that is to say Ure=Ur. Demodulation of the "echo" and measurement of the amplitude of the demodulated signal.

In all of the measurements, the gain factors during transmission and reception and the internal resistance Ri remain the same. The voltage of the line start and thus also the complex value of the "echo" is obtained from the voltage split between Ri and the complex Zc transformed via the transformer and the hybrid. For lines which have load coils, the profile of the "echo" is different from that on lines which do not have load coils, and the demodulated signal is correspondingly different. It is thus possible to identify the presence of load coils from, for example, the profile of the demodulated signal.

The input resistance of the loop (line) is thus measured indirectly by measurement of the received signal. The relationship between the received signal and the transmission signal is measured as the transfer function.

The line test device 102 likewise has line drivers which - controlled by "settings" by the HOST - can, for example, pass differential sine-wave tones to the line. The current can be measured at the driver outputs.

The following text describes how the method can be carried out using the test device:

A differential sine-wave signal of constant amplitude is transmitted, and the amplitude of the driver current is measured. This is different in the case of lines with load coils than in the case of lines without such coils, if the frequency is in a range in which the two characteristic impedances differ to a major extent (at load frequencies). It is thus possible to detect load coils.

Both specific methods are based on the assumption that the line is open at the end and is terminated by a telecommunications system which is currently not active, so that the input impedance of the line is not "corrupted" by a terminating impedance (which is generally in the region of 135 ohms).

Figure 17 once again shows the various areas in which the method is carried out. First of all, the hardware which is used in DSL modems - as already described - is used for measurement. The measurement signals 134 and 135 which are tapped off can be evaluated both by software and by special hardware 131. The subsequent evaluation 132 of the analysis results, which finally produces the result "load coils present/not present", is generally in the form of software.

The input resistance of the line can be measured only indirectly with the aid of the modem: in fact, the entire input resistance of the hybrid is always

measured. Since the transformer impedance has a very major effect on this, the difference in the magnitudes of the input resistances of the hybrid are only very small between lines with or without load coils. It is very difficult to evaluate the measurement results.

The detection of load coils can thus be carried out, in particular, by measurement of the profile of the phase of the input resistance of the hybrid in the frequency range from 1.5 to 5 kHz, and by determination of the gradients. The measurements could be carried out with a step width of 100 to 200 Hz.

Figure 18 and Figure 19 show two different apparatuses for analysis of the phase profile, that is to say for formation of phase difference measured values over the frequency. In the first variant (Figure 18), the mathematical sign (141, and 142) is in each case formed from the transmission signal 134 and from the received signal 135, which are sinusoidal and have no DC voltage component, and are supplied to a (digital) phase discriminator 143. One specific embodiment relating to this will be described further below (Figures 20 and 21).

The variant in Figure 19 shows a quadrature demodulator 150 for formation of phase difference measured values, which carries out quadrature demodulation of the received signal, with the transmission signal (test signal) being used as the carrier.

Figure 20 shows one embodiment for phase measurement using the modem hardware and a simple additional circuit. The corresponding signals are shown in Figure 21. The production and TX filtering of the symbols are carried out such that a sinusoidal transmission signal, without any DC voltage component, is produced at frequencies from 1.5 kHz to 5 kHz. Corresponding to the

voltage split between the line driver internal resistance and the hybrid input impedance, which includes the input impedance of the line 10, this results in a sinusoidal received signal downstream from the analog/digital converter 106b. If the discrete-amplitude transmission signal and received signal are coded using two's complement form, only the most significant bits (that is to say the mathematical signs 210 and 220, which each have a flank 211, 212 and 221, 222 when the mathematical sign changes) are in each case determined and passed on, by supplying them to an exclusive-NOR gate 133. The output signal 230 with the corresponding flanks 231 and 232 of this gate 133 is filtered by means of a low-pass filter 131, whose cut-off frequency is, for example, 100 Hz. The output signal 240 from the low-pass filter is a measure of the phase difference between the transmission signal and the received signal, and can be written for each measurement to a register 132 which can be read by software. The exclusive-NOR gate and the low-pass filter represent a simple coincidence detector.

List of reference symbols

10	Line
11, 12	Feed points
13, 14	Wires
15, 16	Load coils
17	End of the line
18	End of the line section
Zo, Zc	Characteristic impedance
21	Resistance
22	Coil
23	Capacitor
30	Switching element
31	Resistor
32	Capacitor
41	Real part of Zo
42	Imaginary part of Zo
43	Real part of Zc
44	Imaginary part of Zc
a	Value profile of the open line
b	Value profile of the load coil
c	Value profile of the connected line
91	Derivative of the profile
92	Averaging
93	Data reduction
94	Second derivative of the profile
95	Search for a mathematical sign change
96	Mathematical sign change, yes
97	Mathematical sign change, no
100	DSL module
101	Transceiver
102	Line test device
103	Hybrid
104	Transformer
105a	Transmission filter
105b	Digital/analog converter
106b	Analog/digital converter, ADC
106a	Reception filter, RX filter

107	Echo compensation device
FIR echo compensator filter	
107a	Adder
107b	r*4kHz demodulator
108	Sine-wave generator
111 and 112	Signal generation devices
113 and 114	Resistors
115	Evaluation apparatus
Ri	Internal resistor
134 and 135	Measurement signals
131	Specific hardware, low-pass filter
132	Evaluation, register
133	Gate, exclusive-NOR gate
134	Transmission signal
135	Received signal
141, 142	Mathematical sign formation
143	Phase discriminator
150	Quadrature demodulator
210 and 220	Most significant bits (mathematical sign)
211, 212	Flank
221, 222	Flank and
230	Output signal
231 and 232	Flanks
240	Output signal of the low-pass filter

Patent Claims

1. Method for detection of impedances, in particular along inductances, in telephone lines (10) of the type with two metal wires as signal conductors (twisted pair),
characterized by the following method steps:
a test signal in the form of an AC voltage is fed into the telephone line,
a measurement signal of the reflection signal of the test signal is measured, which can be tapped off as the component, reflected on the input impedance of the entire line, of the test signal fed in at the start of the line,
the first method steps are carried out at a number of different frequencies within a preselected frequency range of the AC voltage of the test signal,
the profile of the measurement signals is analyzed as a function of the frequency, with
the derivative (91) of the profile of the measurement signals being formed based on the frequency,
at which point the second derivative (94) of the profile of the measurement signals is formed based on the frequency,
the profile of the second derivative of the profile of the measurement signals based on the frequency is investigated for one or more mathematical sign changes (95).

2. Method for detection of impedances according to Claim 1,
characterized
in that the AC voltage is a sinusoidal AC voltage.

3. Method for detection of impedances according to Claim 1 or 2,

characterized in that the measurement signal is obtained by measurement of the electrical voltage or of the electric current of the reflection signal.

4. Method for detection of impedances according to one of Claims 1 to 3, characterized in that the phase shift of the reflection signal with respect to the test signal is recorded as the measurement signal.

5. Method for detection of impedances according to Claim 4, characterized in that the phase shift is determined by means of a phase discriminator (143).

6. Method for detection of impedances according to Claim 4, characterized in that the phase shift is determined by means of a quadrature demodulator (150).

7. Method for detection of impedances according to one of Claims 1 to 6, characterized in that the input impedance with respect to the frequency is calculated from the measurement signal.

8. Method for detection of impedances according to one of Claims 1 to 7, characterized in that the frequencies are chosen to be between 1 and 5 kHz, in particular with regular or logarithmic intervals between the individual frequencies.

9. Method for detection of impedances according to one of Claims 1 to 8, characterized in that, before the second derivative (94) of the profile of the measurement signals based on the frequency is formed, the individual measurement signals are averaged (92) in order to smooth them in the profile.

10. Method for detection of impedances according to Claim 9, characterized in that median formation is carried out as the smoothing process.

11. Method for detection of frequencies according to one of Claims 9 or 10, characterized in that, in a step which follows the median formation, individual smoothed measurement signals, which are at a regular interval from one another, are supplied for further evaluation.

12. Method for detection of impedances according to one of Claims 1 to 11, characterized in that the inductances are load coils (15, 16).

13. Method for qualification of telephone lines of the type with two metal wires as signal conductors (twisted pair) for suitability for data transmissions which use frequencies above the speech band, on the basis of investigations in particular using a method based on Claims 1 to 12, characterized in that, when a mathematical sign change occurs in a second derivative of the input resistance of the

telephone line over the frequency in a preselected frequency range, the line is assessed as not being suitable for use without further technical actions for data transmissions which use frequencies above the speech band.

14. Method for qualification of telephone lines according to Claim 13,
characterized
in that the frequency range is chosen to be from 1.0 to 5.0 kHz.

15. Use of a DSL modem for carrying out the method according to one of Claims 1 to 14, using the data driver and receiving module which is provided in the DSL modem that is used.

16. Use of a DSL modem (100) for carrying out the method according to one of Claims 1 to 15, using the existing test module which is provided in order to make it possible to pass analog currents and/or voltages of different types to the line and to measure them, in order in this way to make it possible to carry out an electrical test on the input resistance of the line.

17. Use of a DSL modem (100) according to one of Claims 15 to 16,
characterized
in that the DSL modem is an ISDN, VDSL, ADSL, SHDSL or SDSL modem.